TITLE

An Addressable Loudspeaker

BACKGROUND

[0001] There are many ways to make and present a sound recording. The simplest method, and the one used in the earliest sound movies, is called monaural or simply mono. Mono means that all the sound is recorded onto one audio track or channel (a single spiraled groove in a record, for example, or a single magnetic track on a tape), which is typically played on one speaker.

[0002] Two-channel recordings, in which sound is played on speakers on either side of the listener, are often referred to as stereo. Two-channel sound is the standard format for home stereo receivers, television, and frequency-modulation (FM) radio broadcasts. The simplest two-channel recordings, known as binaural recordings, are produced with two microphones set up at a live event (a concert for example) to take the place of a human's two ears. When listening to these two channels on separate speakers, the experience of being present at the event is recreated.

[0003] Surround recordings take this idea a step further, adding additional audio channels so that sound comes from three or more directions. While the term "surround sound" technically refers to specific multi-channel systems designed by Dolby Laboratories, it is more commonly used as a generic term for theater and home theater multi-channel sound systems.

[0004] In a typical home environment, there may be several loudspeakers serving in either a stereo or a surround sound configuration. Traditionally, each loudspeaker has been connected to the surround sound system via a pair of wires. When serving in a stereo configuration or as speakers for a television, two speakers serve as the left and right components. In a typical home theater setup, there may be three additional loudspeakers: front center, rear left, and rear right. In a typical home theater setup, the rear speakers would be furthest away from the amplifier. Consequently, two pairs of wires would have to traverse the room from the amplifier to each speaker, creating both a safety hazard and an eyesore.

[0005] Additionally, some home network configurations include multiple loudspeakers distributed throughout a home. In these network configurations, each

loudspeaker is coupled to the system through an independently run and unsightly control wire. However, in a home with multiple living areas, this additional need for routing independent wires to each loudspeaker may be unsatisfactory to a user.

SUMMARY

[0006] A network includes an audio signal producing device, a content distributor communicatively coupled to the audio signal producing device, a router, a network communication medium communicatively coupling the content distributor and the router, and a plurality of addressable loudspeakers communicatively coupled to the network communication medium, wherein each of the addressable loudspeakers are configured to function as a network peripheral in the home network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The accompanying drawings illustrate various embodiments of the present system and method and are a part of the specification. The illustrated embodiments are merely examples of the present system and method and do not limit the scope thereof.

[0008] **Fig. 1** is a simple block diagram illustrating a home theatre configuration according to one exemplary embodiment.

[0009] **Fig. 2** is a block diagram illustrating a speaker configuration including an addressable loudspeaker according to one exemplary embodiment.

[0010] **Fig. 3** is a simple block diagram illustrating the internal components of an addressable loudspeaker according to one exemplary embodiment.

[0011] **Fig. 4** is a flow chart illustrating a method for transmitting audio to an addressable loudspeaker according to one exemplary embodiment.

[0012] **Fig. 5** is a flow chart illustrating a method for assigning a unique identifier to each component of an addressable loudspeaker system according to one exemplary embodiment.

[0013] **Fig. 6A** is a block diagram illustrating a request for unique identifiers in an addressable loudspeaker configuration according to one exemplary embodiment.

[0014] **Fig. 6B** is a block diagram illustrating an identifier assignment in an addressable loudspeaker configuration according to one exemplary embodiment.

[0015] **Fig. 6C** is a block diagram illustrating the transmission of packetized audio data according to one exemplary embodiment.

[0016] **Fig. 7** is a simple block diagram illustrating the internal components of an addressable loudspeaker according to one exemplary embodiment.

[0017] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements.

DETAILED DESCRIPTION

[0018] The present specification discloses exemplary systems and methods for providing an addressable loudspeaker. More particularly, according to one exemplary embodiment, a loudspeaker is configured with a modem and an amplifier in order to allow a router or other signal directing device to selectively transmit audio data to the addressable loudspeaker. Both the structure and the implementation of the present system and method for incorporating an addressable loudspeaker in a speaker network will be disclosed in detail below.

[0019] As used in the present specification and in the appended claims, the term "loudspeaker" is meant to be understood broadly to include any object that may be used to produce sound by the movement of air in response to a variable current. Additionally, the term "router" is meant to refer to any device or, in some cases, software in a computing device, that determines a network point to which a packet should be forwarded toward its destination. A router may decide which way to send each information packet based on its current understanding of the state of the network(s) it is connected to. A "packet" or "data packet" is meant to be understood broadly as any discrete segment of data. Data signals are typically "packetized," meaning that the data of a message or signal is divided into discrete "packets" or segments of data. Each packet includes a header that identifies the message or object of which that packet is a part and identifies the position of that packet's data within that message or object. Consequently, a receiver of the message can collect the packets of the message or object and reassemble the packetized data into the original message or signal that was transmitted.

[0020] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present

system and method for providing an addressable loudspeaker in a speaker configuration. It will be apparent, however, to one skilled in the art, that the present method may be practiced without these specific details. Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearance of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

Exemplary Structure

[0021] Figure 1 illustrates a surround sound system according to the prior art. As shown in Figure 1, a traditional home-theater system (100) includes an A/V receiver (150) to which a number of audio and video components may be attached. These components may include a videocassette recorder (VCR) (130), a digital video disc (DVD) player (140), a television (110) (e.g., a high-definition or a digital television), a compact disc (CD) player (120), a tape deck, a tuner, a phonograph, an auxiliary amplifier, and/or an upgrade component in order to provide surround sound. As for outputs, which are typically connected to loudspeakers, conventional A/V receivers (150) have two main or front channels (right (160) and left (185)) as well as a number of surround sound channels, including rear right (165) and rear left (180) channels, a center channel (170), and a sub-woofer (175). If a user is listening to the radio, the A/V receiver (150) typically provides audio output on the front right (160) and front left (185) channels only. If the user switches to an input with surround sound capabilities, such as a DVD player (140) or a surround sound broadcast, the A/V receiver (150) provides audio output on the surround sound channels in addition to the front right (160) and front left (185) channels.

[0022] As noted above, each speaker in the traditional home-theater system (100) includes an independent channel and a pair of speaker wires (190) electrically coupling the A/V receiver (150) or other system controller to the speakers. When incorporated into a home networking system, the necessity of routing a pair of independent speaker wires (190) to each loudspeaker is inconvenient and often becomes prohibitive in an existing home.

[0023] Figure 2 illustrates an addressable loudspeaker configuration (200) at a consumer location (205) including a number of addressable loudspeakers (240, 245, 250, 255,

260, 265) according to one exemplary embodiment. According to the exemplary embodiment illustrated in Figure 2, the present speaker configuration (200) includes a stereo system (220) communicatively coupled to a content distribution component (225). In turn, the content distribution component (225) is communicatively coupled to a network communication medium (210). Similarly, a signal router (270) is also communicatively coupled to the network communication medium (210). Moreover, a plurality of addressable loudspeakers (240, 245, 250, 255, 260, 265) are also communicatively coupled to the content distribution system (225) and the signal router (270) through the network communication medium (210).

[0024] The stereo system (220) illustrated in Figure 2 may be any device configured to provide audio signals to an addressable speaker system (200). According to one exemplary embodiment, the stereo system (220) may include, but is in no way limited to, an A/V receiver communicatively coupled to any number of electrical audio signal producing components including, but in no way limited to, a videocassette recorder (VCR), a digital video disc (DVD) player, a television (e.g., a high-definition or a digital television), a compact disc (CD) player, a tape deck, a tuner, a Moving Picture Experts Group Layer-3 Audio (MP3) player, and/or a phonograph player. Regardless of the components communicatively coupled to the stereo system (220), the stereo system is configured to produce an audio signal and transmit that signal to the content distribution component (225) to be packetized and selectively routed to one or more of the addressable loudspeakers (240, 245, 250, 255, 260, 265) of the addressable loudspeaker system (200).

[0025] The content distribution component (225) illustrated in Figure 2 is a component or firmware operating on a computing device configured to provide an interface to a user. The interface provided to a user presents a number of options for each addressable loudspeaker (240, 245, 250, 255, 260, 265) communicatively coupled to the present system. According to one exemplary embodiment, the content distribution system (225) is configured to provide a user with options for each addressable loudspeaker (240, 245, 250, 255, 260, 265) through a user interface (not shown) including, but in no way limited to, OFF mode, monaural mode, stereo left channel mode, or stereo right channel mode. While the exemplary embodiment illustrated above lists a number of user options for each addressable loudspeaker, any number of loudspeaker control and/or audio effect options may be presented to the user according to the present system and method. The content distribution component

(225) also functions as a modulator configured to modulate incoming audio signals into packetized audio data. Upon selecting a content distribution condition for a desired addressable speaker, the audio signal may be packetized, and the sound and operation condition may then be transmitted to the desired addressable speaker with the aid of the signal router (270).

[0026] The signal router (270) illustrated in Figure 2 may be a device configured to determine a network point to which a packet should be forwarded toward its destination. The signal router (270) may decide which way to send each audio packet based on its current understanding of the state of the networks it is connected to. The signal router (270) may also create or maintain a table of the available routes and use this information to determine the best route for a given data packet. Note that the present system may operate without the aid of a personal computer (PC). In contrast to incorporating a PC to perform the routing function, the present system and method reduces cost by incorporating a single dedicated router (270) configured to route packetized audio data. The inclusion of a dedicated router (270) eliminates computational resource allocation problems often associated with PCs. Additionally, the incorporation of a signal router (270) into the present system reduces the amount of space occupied by the system, when compared to a system that incorporates a PC, while still maintaining the functionality of incorporating addressable speakers into the system.

[0027] The network communication medium (210) that communicatively couples the above-mentioned components to the addressable speakers (240, 245, 250, 255, 260, 265) facilitates the transmission of the audio signal packet between components. As illustrated in Figure 2 and in the remainder of the present specification, the network communication medium (210) is described in the context of a power line based network medium. A power line based network medium may be any power line infrastructure used to provide power to multiple locations in a user location. For example, a power line based network medium may include the wires in a house used to provide 110 V power to household appliances. However, the present system and method may be applied to a network incorporating addressable speakers coupled by any network communication medium capable of supporting packetized data transmission including, but in no way limited to, a wireless communication medium such as infrared or radio frequency mediums, a phone line communication medium, or an Ethernet communication medium. The exemplary embodiment illustrated in Figure 2 is merely

described in the context of a power line based network communication medium (210) for ease of explanation and because the ubiquity of electrical outlets in a residence makes it possible to place addressable loudspeakers virtually in any room.

[0028] The addressable loudspeakers (240, 245, 250, 255, 260, 265) that are communicatively coupled to the network communication medium (210) in the exemplary embodiment illustrated in Figure 2 include a unique network identification address and may selectively be routed packetized audio signals. The components of the present addressable loudspeakers (240, 245, 250, 255, 260, 265) allow the addressable loudspeakers to work like a network peripheral with embedded capability to decode and amplify audio as well as attach themselves to a network using commonly used network protocols as described below.

[0029] Figure 3 further illustrates the components of an addressable loudspeaker. As illustrated in Figure 3, one exemplary embodiment of the present addressable loudspeaker (300) includes an addressable modem (310) communicatively coupled to the network communication medium (210) previously mentioned. The addressable modem (310) is then coupled to a signal amplifier (320). The signal amplifier (320) is subsequently coupled to and configured to drive a speaker (330).

[0030] The addressable modem (310) that forms a part of the addressable loudspeaker (300) according to the exemplary embodiment illustrated in Figure 3, includes a unique network address that allows the content distribution component (225; Fig. 2) of the present exemplary system to address packetized audio data to each addressable loudspeaker (300) independently using the router (270; Fig. 2). According to one exemplary embodiment, the unique address assigned to the addressable modem (310) is an Internet protocol (IP) address comprising a 32-bit number. Alternatively, the unique address may be, but is in no way limited to, a 48-bit Ethernet address. The unique address that is assigned to the addressable modem (310) may be preset by the modem manufacturer, user settable, and/or automatically configured by the router (270; Fig. 2) as described in further detail below. Additionally, the addressable modem (310) is configured to selectively receive addressed analog data packets representing a desired audio signal to be broadcast by the addressable loudspeaker (330) and demodulate the transmitted data packet signals into audio signals that may then be amplified and used to produce the desired audio signal in the speaker (330).

[0031] The amplifier portion (320) of the addressable loudspeaker (300) illustrated in Figure 3 is configured to amplify the received audio signal sufficiently to drive the speaker portion (330) of the addressable loudspeaker (300). The amplifier portion (320) of the addressable loudspeaker is a power amplifier and may include, but is in no way limited to a bipolar transistor or a vacuum tube. The amplifier (320) is configured to both receive the audio signal from the modem (310) and increase the voltage of the audio signal sufficient to drive the speaker portion (330) of the addressable loudspeaker (300). Additionally, in an exemplary embodiment where the network communication medium (210) is not a power line based network, the amplifier (320) may be coupled to a secondary power source (not shown) and have a power control unit in the form of an external knob or circuitry that may be controlled by the stereo system (220; Fig. 2) through data transmitted with the above-mentioned audio signal.

[0032] The speaker portion (330) of the addressable loudspeaker (300) illustrated in Figure 3 comprises conventional speaker hardware including, but in no way limited to, a speaker cone, a coil, and magnets. The speaker portion (330) is configured to vibrate in proportion to a change in the current of the audio signal provided by the amplifier (320) thereby producing the desired audio sound.

[0033] The present system and method for incorporating an addressable loudspeaker in a speaker configuration is described herein in the context of a surround sound speaker system. However, the present system and method are in no way limited to a surround sound system. To the contrary, the present system and method may be incorporated into any number of home or automobile networks including, but in no way limited to, home networks, security systems, monitoring systems, public address (PA) systems, and the like.

Exemplary Implementation and Operation

[0034] Figure 4 illustrates a method for selectively transmitting audio signals to an addressable loudspeaker according to one exemplary embodiment. As illustrated in Figure 4, the present method begins by assigning unique network identifications to each component communicatively coupled to the network (step 400). Once each component of the network has been assigned unique network identifications, the desired addressable loudspeakers for a determined audio signal are identified (step 410). Once the addressable loudspeakers are

determined, the received audio signal is converted into packets of audio data (step 420) and the packets of audio data are selectively routed to the identified addressable speakers (step 430) by a signal router. Once received in the modems of the assigned speakers (step 440), the audio packets are converted into a continuous analog audio signal (step 450) and amplified by the amplifier (step 460). Once amplified, the analog audio signal is then used to drive the speaker portion of the addressable loudspeaker (step 470). The above-mentioned method will be further described in detail below with reference to Figures 5 – 6C.

[0035] As described above and in Figure 4, the present method begins by assigning a network identification to each system component (step 400). One exemplary method for assigning a unique network identification to each system component (step 400) is illustrated in Figure 5. As illustrated in Figure 5, the assignment of unique network identifications may begin by each addressable loudspeaker requesting an IP address from the system router (step 500) according to one exemplary embodiment. The above-mentioned request (step 500) may be performed by a signal transmitted from the modem of the addressable loudspeaker. Alternatively, the request for unique network identification may be performed automatically if an addressable loudspeaker is detected on the network. Once requested, an IP address is assigned to each addressable loudspeaker by the system router (step 510). Upon assignment of an IP address to each addressable loudspeaker, the content distribution component also requests an IP address from the system router (step 520) and the system router assigns a unique IP address to the content distribution component (step 530). With all of the system components assigned a unique IP address, a user may then initiate the transmission of an identified audio signal to an addressable loudspeaker by making a selection from a content distribution options list (step 540).

[0036] Figure 6A further illustrates the request for a unique network address by a number of addressable loudspeakers (300-1, 300-2, 300-3) and a content distribution component (225). As illustrated in Figure 6A, each of the above mentioned components transmits a signal to the signal router (270) requesting a unique network address. As illustrated in Figure 6B, once the request has been received by the signal router (270), a unique IP or other network identification address is assigned and transmitted to each component for storage. Additionally, the signal router (270) may also store the unique network identification addresses in a configuration table (not shown). The configuration table

is a collection of information that includes data on which connections lead to a particular addressable loudspeaker (300-1, 300-2, 300-3), priorities for connections to be used, and rules for handing signal traffic.

[0037] Returning again to Figure 4, once the system components have been assigned unique IP addresses (step 400), audio data may be prepared for selective transmission to the addressable loudspeakers. In order to prepare the audio signals for transmission to the addressable loudspeakers, the addressable speakers to receive the audio signal is identified (step 410) and the audio signal is converted into packets for transmission (step 420) by the content distribution component (225; Fig. 2).

[0038] Identification of the addressable loudspeakers to receive the audio signal may be performed via a user interface provided by the content distribution component (225). According to one exemplary embodiment, the content distribution component is configured to allow a user to designate which addressable loudspeakers are to receive a specified audio signal. According to this embodiment, the user interface presents a number of control options for each addressable loudspeaker including, but in no way limited to, OFF, monaural mode, stereo left channel mode, or stereo right channel mode. A number of additional audio and/or loudspeaker control options may also be presented by the user interface according to the present system and method.

[0039] When converting the audio signal into packets, the content distribution component (225; Fig. 2) modulates a received audio signal. When modulating the audio signal into packets, the content distribution component (225; Fig. 2) includes header information at the beginning of each audio signal packet identifying a specific addressable loudspeaker, by its IP address, which is to receive the audio data packets. Additionally, according to one exemplary embodiment, the header information may contain one of the above-mentioned control options and/or a volume level to be applied to the amplifier.

[0040] With the audio data packets appropriately formatted, they may then be routed to the identified addressable loudspeaker (step 430). Figure 6C illustrates the transmission of an audio data packet into the present audio system (200). As illustrated in Figure 6C, the content distribution unit (225) introduces the packetized audio data onto the network. Once introduced to the network, the signal router (270) sees the packetized data and analyzes the header information. The signal router (270) analyzes the header information of

each packet searching for the recipient addressable loudspeaker's address. Once the recipient addressable loudspeaker's address is found on the packetized data, the router accesses the configuration table and matches the found address with the rules of the configuration table. The rules of the configuration table will indicate a specific direction for the identified packetized data to be transmitted. Once a path is identified by the signal router (270), the signal router will check the performance of the primary connection with a number of alternative routes and an optimal route will be selected and the signal will be transmitted. Once transmitted, the signal router (270) will then handle the next packet.

[0041] Returning again to Figure 4, once the packetized audio signal has been transmitted to the appropriate addressable loudspeaker (step 430), the signal is received by the modem of the assigned loudspeaker (step 440). When received in the assigned loudspeaker, the modem may again check the header information of the packetized audio signal to assure that the packet is to be received by that specific assignable loudspeaker. The modem may then convert the packetized data into a continuous analog audio signal (step 450) that may then be amplified (step 460) and applied to the speaker to produce a desired audio signal (step 470) according to methods well known in the audiophile arts.

Alternative Embodiments

[0042] According to one alternative embodiment illustrated in Figure 7, an addressable loudspeaker (700) coupled to a network communication medium (210) may include the components listed above. Specifically, the addressable loudspeaker (700) may include a modem (710), an amplifier (720), and a speaker portion (730). However, the addressable loudspeaker (700) illustrated in Figure 7 also includes a microphone (740) communicatively coupled to the modem (210).

[0043] According to this exemplary embodiment, the combination of a microphone (740) and a modem (710) in each addressable loudspeaker (700) increases the utility of the addressable loudspeaker. For example, the incorporation of the microphone (740) into the addressable loudspeaker (700) makes it possible for the loudspeaker to be used as a remote microphone for system calibration. According to this exemplary embodiment, a test tone may be transmitted to a first addressable loudspeaker (700) via a router (270; Fig. 6C) as described above. When the test tone is emitted from the designated addressable

loudspeaker, the other addressable loudspeakers (700) monitor the test tone levels. The test tone levels may then be modulated by the modems (710) and transmitted, via the router (270; Fig. 6C), to the stereo system (225; Fig. 2). This configuration will allow a surround sound system to calibrate itself by compensating for room acoustics, room relaxation constants, speaker placement and associated delays, as well as speaker efficiency.

[0044] Additionally, the presence of a microphone (740) in the addressable loudspeaker (700) as illustrated in Figure 7, may allow the network to function as an intercom or as a remote security monitoring system. According to this exemplary embodiment, the sounds in a consumer location (205; Fig. 2) could be monitored anywhere there was a programmable loudspeaker (700) by modulating the picked up sounds and transmitting them, with the aid of the router (270; Fig. 6C) to a desired location.

[0045] In yet another alternative embodiment, the addressable loudspeaker configuration may vary from that illustrated in Figures 3 and 7. According to this alternative embodiment, the modem, amplifier, and/or microphone components of the addressable loudspeaker are not integrated with the speaker. Rather the modem, amplifier, and/or microphone components may be independent from the speaker. This configuration allows a consumer to couple the modem, amplifier, and /or microphone components to a speaker of their choice.

[0046] In conclusion, the present system and method for providing an addressable loudspeaker in a network allows for a cost efficient method for selectively transmitting audio signals to specific speakers on a network. More specifically, the present system and method reduce the cost traditionally associated with networks including addressable loudspeakers because there is no need for a personal computer since the inclusion of a router performs the packet routing functions. Elimination of a PC reduces system cost while maintaining addressable loudspeaker functionality. Additionally, the present system and method reduces network costs by eliminating the need for the routing of individual wire pairs to each and every loudspeaker in the network. Rather the presents system and method uses existing network mediums such as power lines, wireless mediums, or phone lines. Additionally, the present system and method increases the functionality of a speaker network by allowing the network to function as an intercom system or a remote security monitoring system.

[0047] The preceding description has been presented only to illustrate and describe embodiments of the present system and method. It is not intended to be exhaustive or to limit the present system and method to any precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the present system and method be defined by the following claims.